Thalamus, Hypothalamus and Limbic System

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By the end of this lecture the student will be able to:
- List the nuclear groups of the thalamus.
- List the thalamic connections with the different centers.
- Describe why the thalamus is important center and list its functions.
- Describe the functions of hypothalamus.
- List the component of the limbic system & describe its functions.

THALAMUS
Gateway to the cerebral cortex

- participates in sensory, motor and integrative functions.
- all information reaching the cortex is processed by the thalamus at first, so called gateway to cerebral cortex.

Thalamic nuclei:

Functionally; *the thalamus can be divided into nuclei that project diffusely to wide region of the neocortex and nuclei that project to specific discrete portions of neocortex and limbic system:*

Thalamic connections:

(A) Nonspecific projection nuclei:
- These include mainly the ***midline*** *&* ***intralaminar*** *nuclei.*
- They receive signals from the *reticular formation.*
- *They project to almost all areas (non specific area) of the cerebral cortex.*

(B) Specific projection nuclei:

(1) Ventro-posterior nucleus (VPN):

- Its lateral part (VPLN) receives the *spinal and medial lemnisci.*
Its medial part (VPMN) receives the *trigeminal lemniscus.*
- Both parts project to the cortical sensory areas in the postcentral gyrus.

(2) Lateral geniculate body (LGB):

- This projects *visual impulses* to the occipital lobe.

(3) Medial geniculate body (MGB):

- This projects *auditory impulses* to the temporal lobe.

(4) Ventroanterior (VA) & Ventrolateral nucleus (VL)

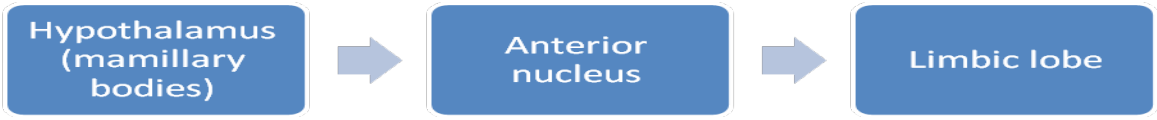
(thalamic motor nuclei):

- This receives signals from both the *cerebellum and the basal ganglia.* - Projects to the *cortical motor areas.*
- Playing a major role in the control of motor functions.

(5) Anterior nucleus:

- This receives signals from the *hypothalamus.*
- Project to the *cortical limbic lobe.*

- involved in memory and emotions.



(6) **Dorsomedial and dorsolateral nuclei** *(association nuclei)*

- *Receive* signals from other thalamic nuclei.
- *Project to the cortical association areas.*

In summary:

Input= Receive from	Thalamic nucleus	Output= Project to	
Non specific projection thalamic nuclei			
Specific projection thalamic nuclei (Sensory area ... sensory ... yrus) ... ital) ... poral)			
Cerebellum & Basal ganglia	VA & VL	Cortical motor area	Motor
Hypothalamus (Mamillary bodies)	Anterior nucleus	Cortical limbic lobe	
Higher integrati ... ation)			

FUNCTIONS OF THALAMUS:

(1) Conveys all sensations to the cerebral cortex *except olfaction,* because its nuclei are *relay stations* in the pathways of:

(a) Epicritic (fine) sensations from the opposite side (VPN).

(b) Visual signals (LGB).

(c) Auditory signals (MGB).

****Recently it was reported that part** of the *olfactory sensation also relays in the thalamus.*

(2) Centre for perception of protopathic sensations (crude touch, slow pain) from the opposite side (VPN & intralaminar and midline nuclei).

(3) Relay station for signals from the *contralateral cerbellum and ipsilateral basal* ganglia to the cortical motor areas (VL).

(4) The nonspecific projection nuclei are relay station in the *ascending reticular activating system* (ARAS).

(5) Part of the systems concerned with:

(a) *Memory and emotional reactions* (through its connections with the hypothalamus and limbic lobe).

(b) *Higher intellectual functions* (through its connections with the cortical association areas).

(c) *Behaviour and personality* (through its connections with the prefrontal cortical areas).

	Sensory	**Motor**	**Integrative**
ARAS (SLEEP & CONCIOUSNESS)	- Relay station for all epicritic sensations, vision and hearing. - Center of perception of protopathic sensations	- Relay station for signals from contralateral cerebellum, epsilateral basal ganglia	-Memory and Emotions -Personality and behavior -Higher intellectual functions

HYPOTHALAMUS
The major homeostatic organ

- major component of the limbic system.

Functions:

The hypothalamus is essential for homeostasis through the following:

(1) **Control of autonomic functions**:
The anterior nuclei control ***parasympathetic*** functions while the posterior and lateral nuclei control ***sympathetic*** functions.

(2) **Control of the endocrine system**:
This occurs by 2 ways:
*A- **Nervous** control*: The hypothalamus controls 2 endocrine glands by sending nerve signals:
(a) *The adrenal medulla* (through affecting the vasomotor centre)
(b) *The posterior pituitary gland* (through the *hypothalamo-hypophysial tract).* The hormones of this gland (ADH and oxytocin) are also synthesized in the hypothalamus (Supraoptic & Paraventricular nuclei).
*B- **Hormonal** control*: The hypothalamus controls the *anterior pituitary gland* (and consequently most other endocrine glands) by releasing the *hypophysiotropic hormones* from its *median eminence*.

(3) **Control of food intake**:
This occurs by activity of the *hypothalamic appetite center* (appestat), which is subdivided into 2 parts:

(a) A **feeding center** in the lateral nuclei: This centre is continuously active. Its stimulation increases the appetite and its damage causes *anorexia.*

(b) A **satiety center** in the ventromedial nucleus: Stimulation of this center decreases the appetite by inhibiting the activity of the feeding center, while its damage increases the appetite and leads to *hyperphagia.* In hypoglycemia, the satiety center is inhibited, and this increases the activity of the feeding center.

(4) **Control of water balance**:
This occurs by the hypothalamic *osmoreceptors* which regulate both water intake and water loss as follows:

(a) ***Water intake***: This occurs through affecting activity of the *thirst center (lateral nuclei),* which leads to drinking when stimulated e.g. in cases of dehydration.

(b) ***Water loss***: This occurs through adjusting release of *ADH* from the posterior pituitary gland, which controls the urinary water loss.

(5) **Regulation of body temperature**:
The hypothalamus contains *sensitive* ***thermoreceptors*** as well as the ***thermoregulatory center***. The latter consists of a ***heat loss center*** in the anterior nuclei and a ***heat gain center*** in the posterior nuclei.

(6) **Regulation to sleep**:

a) The hypothalamus contains ***sleep center*** *(Diencephalic sleep zone in posterior hypothalamus).*

b) ***Control of circadian*** *(diurnal or 24 hours) rhythms*: This occurs by the ***Suprachiasmatic nuclei*** which are the pacemakers for the circadian rhythms in the body (e.g. the rhythms in the secretion of *ACTH and melatonin,* the *sleep-wake cycles and the* body *temperature rhythm).* These nuclei receive signals from the eyes (via the *retino-hypothalamic fibers)* and their function is to synchronize the various body rhythms to the 24-hour light-dark cycle.

(7) **Control of motivation** by the *reward & punishment systems*.

& **Control of emotions** and **behavior** with limbic system.

LMBIC SYSTEM

Functions:

1- **Olfaction (Smell)**
Limbic system is responsible for:
-Perception and discrimination of olfactory stimuli (Piriform cortex).
-Emotional reactions associated with olfactory stimuli (Amygdala).
-Olfactory memory (Entorhinal cortex).

2- **Control of autonomic response**
Limbic stimulation produces autonomic effects (e.g. changes in ABP, respiration) which are parts of the emotional responses.

3- **Control of feeding behavior**
Limbic system is involved in the neuronal regulation of appetite. Lesions of amygdaloid nuclei → hyperphagia (increase eating) and amniophagia (indiscriminative ingestion of all kinds of food).

4- **Maternal and sexual behavior**
Limbic system is important for normal maternal behavior and is concerned with emotional expression during the sexual act.

5- **Control of emotions**
Both hypothalamus and limbic system particularly the amygdaloid nuclei, control various emotional responses. Stimulation of these nuclei produces fear. Emotions may be associated with:
1- Autonomic response: Changes in HR, ABP, respiration, sweating, pupillodilatation.
2- Endocrine response: Release of CRH, CAs during stress.
3- Somatic response: Exaggerated reflexes in anxiety.

6- **Relation to memory**

Hippocampus is the site of encoding and consolidation of short term memory.
Bilateral lesion of hippocampus leads to anterograde amnesia.

7- **Motivation**
Def.: It is the force that activates or inhibits certain behavior to achieve certain goal. Limbic system has two centers that control motivation:

a) **Reward (approach) system:** Lateral and ventromedial nuclei of the hypothalamus & part of Amygdaloid nucleus. Its stimulation leads to pleasure, satisfaction and ecstasy; so continue doing the act (Repitition).
b) **Punishment (avoidance) system:** Periventricular nucleus of the hypothalmus and Periaquductal gray area & part of Amygdaloid nucleus. Its stimulation leads to displeasure, fear and terror; so stop doing the act (Avoidance).

SUGGESTED TEXTBOOKS

1. Ganong's review of medical physiology 25th edition
2. Guyton and Hall 13th edition